Health Consultation

Palermo Well Field Ground Water Contamination
Tumwater, Thurston County, Washington

January 29, 2002

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Foreword

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that DOH can respond quickly to requests from concerned residents or agencies for health information on hazardous substances. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

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Glossary

Acute	Occurring over a short period of time. An acute exposure is one which lasts for less than 2 weeks.
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate it's ability to cause cancer in humans.
Carcinogen	Any substance that can cause or contribute to the production of cancer.
Chronic	A long period of time. A chronic exposure is one which lasts for a year or longer.
Comparison value	A concentration of a chemical in soil, air or water that, if exceeded, requires further evaluation as a contaminant of potential health concern. The terms comparison value and screening level are often used synonymously.
Contaminant	Any chemical that exists in the environment or living organisms that is not normally found there.
Dose	A dose is the amount of a substance that gets into the body through ingestion, skin absorption or inhalation. It is calculated per kilogram of body weight per day.

Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a *comparison value* used to select contaminants of potential health concern and is based on ATSDR's *minimal risk level* (MRL).
Exposure	Contact with a chemical by swallowing, by breathing, or by direct contact (such as through the skin or eyes). Exposure may be short-term (acute) or long-term (chronic).
Groundwater	Water found underground that fills pores between materials such as sand, soil, or gravel. In aquifers, groundwater often occurs in quantities where it can be used for drinking water, irrigation, and other purposes.
Hazardous substance	Any material that poses a threat to public health and/or the environment. Typical hazardous substances are materials that are toxic, corrosive, ignitable, explosive, or chemically reactive.
Lowest Observed Adverse Effect Level (LOAEL)	LOAELs have been classified into "less serious" or "serious" effects. In dose-response experiments, the lowest exposure level at which there are statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An amount of chemical that gets into the body (i.e., dose) below which health effects are not expected. MRLs are derived by ATSDR for acute, intermediate, and chronic duration exposures by the inhalation and oral routes.

No apparent public health hazard	Sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.
No Observed Adverse Effect Level (NOAEL)	The dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be observed at this dose but were judged not to be "adverse."
Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides which are not easily dissolved in water.
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE.
Plume	An area of contaminants in a specific media such as groundwater.
Remedial investigation	A study designed to collect the data necessary to determine the nature and extent of contamination at a site.
U.S. Environmental Protection Agency (EPA)	Established in 1970 to bring together parts of various government agencies involved with the control of pollution.
Volatile organic compound (VOC)	An organic (carbon-containing) compound that evaporates (volatilizes) easily at room temperature. A significant number of the VOCs are commonly used as solvents.

Background and Statement of Issues

DOH prepared this health consultation in response to a request from the U.S. Environmental Protection Agency (EPA) to evaluate the results of indoor air samples collected at seven residences located within the Palermo Wellfield Superfund site (site) in Tumwater, Washington. DOH prepares health consultations under a cooperative agreement with the Agency for Toxic Substances and Disease Registry.

The site includes the wellfield and the Palermo neighborhood, both located in the Deschutes River Valley, and the commercial area to the west. The Palermo Wellfield consists of six wells that provide up to 50% of the drinking water for the city of Tumwater. The samples were taken to determine whether residents are being exposed to contaminants believed to have migrated from groundwater into residential indoor air. The health consultation evaluates whether exposures exceed a level of health concern.

In April 1997, the site was added to EPA's National Priorities List (NPL) as a result of trichloroethylene (TCE) detections in several of the city's drinking water supply wells, and later, TCE and tetrachloroethylene (PCE) detections in soil and groundwater west of the wellfield. The contamination is believed to have originated from several businesses in the commercial area upgradient (west) of the wellfield and west of the Palermo neighborhood, near the intersection of Capitol Boulevard and Trosper Road (Figure 1). Information collected during the Remedial Investigation (RI) indicate that PCE and TCE are present in two distinct groundwater plumes, which were believed to have flowed with the groundwater to the base of the Palermo Bluff located above residences in the Palermo Valley. As the contaminated groundwater surfaced at the base of the Bluff, it is believed to have collected in low areas and crawl spaces underneath residences along Rainier Avenue (Figure 2).

Computer modeling conducted by EPA indicated that TCE and PCE in surface water beneath homes could move into indoor air and pose a health risk to residents. To eliminate this risk, EPA constructed a subdrain system designed to lower the water table in the vicinity of the affected residences. Although construction of the subdrain has been completed, evaluation of its effectiveness is ongoing.

Since EPA relied upon the results of the air model to assess the potential indoor air health hazard posed by PCE and TCE in crawl space water, residential indoor air sampling was not conducted prior to implementation of the subdrain system. Indoor air sampling was conducted only after implementation of the subdrain system in order to assess the existence and concentration of PCE and TCE.

Air Sampling Methods and Results

Residential indoor air sampling was conducted in late March and late August 2001. Although attempts were made to collect samples from 15 homes in the Palermo neighborhood, participation

was limited, and only seven homes were tested. Five of these homes are located in the portion of the neighborhood with the highest groundwater levels and the highest groundwater concentrations of PCE and TCE. Twenty-four hour samples were collected using flow controllers attached to 6-liter summa canisters. Samples were collected from the crawl space and living space in five of the homes. One home had no crawl space, and access to the living space in another home could not be obtained. As a result, only one air sample was collected from each of these two homes. Background outdoor air samples were collected during both sampling rounds from the backyard of one of the seven residences. The sampler was hung from an outdoor lighting fixture positioned approximately head-height.

Background

Background is defined here as the concentration of PCE and TCE expected to be present in air without any known contribution from a particular source. Since studies have shown that PCE and TCE are frequently present at low levels in urban indoor and outdoor air, it useful to compare the expected level to the measured level(s) in order to determine whether the measured level(s) may be higher due to an identified source.

PCE was detected in the living space of one residence, and in the living space and crawl space of another residence. TCE was detected in the living space and crawl space of one residence. Neither PCE nor TCE were detected above the 1 microgram per cubic meter reporting limit at the background locations.

PCE and TCE concentrations were low in the residences where it was detected, and are discussed in more detail below, relative to their potential health impacts.

Discussion

Tetrachloroethylene (PCE)

PCE is a manufactured compound widely used for dry cleaning fabrics and as a metal degreaser. It is also used as an intermediate in the manufacturing of other products. It is a nonflammable liquid at room temperature, evaporates easily into the air, and has a sharp, sweet odor. Most people can begin to smell PCE when it is present in the air at or above a level of 100 parts per billion (ppb). Levels of PCE at both Palermo residences where it was detected were over 300 times below this odor level.

Non-cancer toxicity:

Since the maximum concentration of PCE detected in indoor air was over 100 times lower than ATSDR's non-cancer health comparison value (i.e., 272 micrograms per cubic meter chronic EMEG), *exposures to the levels detected are not expected to result in noncarcinogenic health effects.*

Cancer toxicity:

The carcinogenicity characterization has a long history. A July 1985 Health Assessment document for PCE classified it as a Group C (possible human) carcinogen, but indicated that it would be reevaluated based on new information. An April 1987 addendum to the Health Assessment document proposed that it be classified as a B2 (probable human) carcinogen, and provided a revised inhalation risk estimate. A February 1991 document discussed newer data relative to weight-of-evidence classification. The EPA's Science Advisory Board has determined that these documents are technically adequate, and offered an opinion that the weight-of-evidence is on C-B2 continuum (possible human carcinogen/probable human carcinogen). Currently, the Agency has not adopted a final position on the weight-of-evidence classification. The International Agency for Research on Cancer (IARC) considers PCE as a Class 2A carcinogen (probably carcinogenic to humans, based on limited human evidence and sufficient evidence in animals). The U.S. Department of Health and Human Services determined that it may reasonably be anticipated to be carcinogenic to humans.

Although a number of human studies (primarily epidemiology studies of dry-cleaning workers) suggest the possibility of increased cancer incidences from exposure to PCE, particularly esophageal and bladder cancers, it has not been shown to definitively cause cancer in humans. Other cancers suspected of being associated with exposures to high levels of PCE (thousands of times higher than levels measured in Palermo residences) include intestinal, pancreatic, lung, kidney, skin, colon, and lymphatic/hematopoietic cancer. Following inhalation exposure to PCE, mononuclear cell leukemia was observed in rats and hepatic tumors were observed in mice. However, because both mononuclear cell leukemia and hepatic tumors are common in rats and mice, respectively, the relevance of these tumors to humans is not clear.

The concentrations of PCE in indoor air detected in the two Palermo residences were from over 300,000 to over 600,000 times lower than the cancer effect levels (CEL) derived in the rodent studies discussed above. Although the cancer slope factor for PCE has been removed pending the reassessment, the previous slope factor can be used to estimate cancer risk. *The estimated increased chance of developing cancer from chronic exposure to the maximum detected concentration of PCE in indoor air is insignificant, approximately one additional cancer in a population of ten million persons exposed.* Some or all of this estimated risk can be attributed to background levels of PCE commonly found in the indoor air of urban residences (Table 3).

Trichloroethylene (TCE)

TCE is primarily used as a metal degreaser. The primary users of this compound are the automotive and metals industries. It is also found in some household products, such as typewriter correction fluid, paint removers, adhesives, and spot removers. Most people can begin to smell TCE in air at or above 100,000 parts per billion. Levels of PCE in the single Palermo residence where it was detected were about 100,000 times below this odor level.

The National Center for Environmental Assessment (NCEA) is currently finishing a revised human health risk assessment on TCE. This assessment will present EPA's most current evaluation of the potential health risks from exposure to TCE. TCE exposure is associated with a number of adverse health effects, including neurotoxicity, immunotoxicity, developmental toxicity, liver toxicity, kidney toxicity, endocrine effects, and several forms of cancer. The mechanistic information suggests some risk factors that may make some populations more sensitive, and that TCE could affect children and adults differently.

Non-cancer toxicity:

Although a chronic-duration inhalation health comparison value (MRL, or minimal risk level) is currently not available, ATSDR has derived an intermediate-duration MRL of 537 $\mu g/m^3$ (100 ppb) for inhalation exposure to TCE. The MRL is based on neurological effects on rats observed in a 1994 study. An EPA inhalation reference concentration (RfC) of 40 $\mu g/m^3$ has also been derived, and is based on critical effects in the central nervous system, liver, and endocrine system.

TCE concentrations measured in indoor air at the single residence where it was detected were 100 to 170 times lower than the MRL, and seven to 13 times lower than the RfC, indicating that neurological or other non-carcinogenic health effects would not be expected.

Cancer toxicity:

Mechanistic research indicates that TCE-induced carcinogenesis is complex, involving multiple carcinogenic metabolites acting through multiple modes of action. In 1985, EPA classified TCE as a probable human carcinogen. Three years later EPA reviewed information suggesting the weight-of-evidence was on a possible human carcinogen - probable human carcinogen continuum. Under EPA's proposed (1996, 1999) cancer guidelines, TCE can be characterized as "highly likely to produce cancer in humans." These findings are consistent with those of the International Agency on Research of Cancer (IARC, 1995) and the National Toxicology Program (NTP, 2000). As a result of the reassessment, EPA withdrew the inhalation and oral unit risk values.

In experimental rodent studies, high doses of TCE administered to mice resulted in tumors of the lungs, liver, and testes. Other possible cancers associated with exposure to high levels of TCE include cancer of the bladder, stomach, prostate, kidney, and pulmonary system.

TCE cancer effects levels (CELs), which were derived from lowest observed adverse effects levels (LOAELs) in chronic-duration studies on rats and mice, ranged from 100,000 ppb to 600,000 ppb. *The levels of TCE measured in Palermo residential indoor air samples were from 100,000 to 600,000 times lower than these CELs.*

In order to estimate cancer risk for persons assumed to be chronically exposed to the detected levels of TCE in indoor air, the previous EPA inhalation slope factor was used. *The estimated increased cancer risk was slight, approximately one additional cancer in a population of one million persons exposed over many years.* As with PCE, some or all of this estimated risk can be attributed to background levels of TCE commonly found in the indoor air of urban residences (Table 3).

Background Levels of PCE and TCE in Indoor Air:

PCE and TCE concentrations measured in Palermo residential indoor air were at levels consistent with those often found in indoor urban environments.

The presence of contaminants in ambient and indoor air in urban areas has been well established. It is also clear that levels of VOCs in indoor air are consistently higher than those found in ambient air. Table 3 and Table 4 below shows the maximum concentrations of PCE and TCE measured at Palermo residences, compared to background indoor and outdoor air concentration ranges, based on various U.S. studies.

Based on the small number of Palermo residences where PCE and/or TCE was detected and tested (three out of seven residences tested), it is impossible to definitively ascertain the source of these contaminants. Although the contaminated groundwater may be the source, the levels of PCE and TCE detected in Palermo residential indoor air are also similar to those expected in a typical, urban indoor-air environment (i.e., background).

Table 1. *PCE and TCE indoor air concentrations (in micrograms/cubic meter)*

House 1					
March 28, 2001			August 22, 2001		
Living Space	PCE	2.1 (= 0.31 ppb)	Living Space	PCE	1.8 (= 0.27 ppb)
	TCE	ND		TCE	ND
Crawlspace	PCE	ND	Crawlspace	PCE	ND
	TCE	ND		TCE	ND
House 2					
March 28, 2001			August 22, 2001		
Living Space	PCE	Not tested	Living Space	PCE	Not tested
	TCE	Not tested		TCE	Not tested
Crawlspace	PCE	ND	Crawlspace	PCE	ND
	TCE	ND		TCE	ND
House 3					
March 28, 2001			August 22, 2001		
Living Space	PCE	ND	Living Space	PCE	Not tested
	TCE	ND		TCE	Not tested
Crawlspace	PCE	Not tested (no crawlspace)	Crawlspace	PCE	Not tested
	TCE	Not tested (no crawlspace)		TCE	Not tested

ND = not detected

Table 1 (cont.) *PCE and TCE indoor air concentrations (in micrograms/cubic meter) Palermo Valley residences, Tumwater, Washington*

House 4					
March 28, 2001			August 22, 2001		
Living Space	PCE	ND	Living Space	PCE	ND
	TCE	3.1 (= 0.58 ppb)		TCE	2.2 (= 0.41 ppb)
Crawlspace	PCE	ND	Crawlspace	PCE	ND
	TCE	5.6 (= 1 ppb)		TCE	4.6 (= 0.86 ppb)
House 5					
March 28, 2001			August 22, 2001		
Living Space	PCE	ND	Living Space	PCE	ND
	TCE	ND		TCE	ND
Crawlspace	PCE	ND	Crawlspace	PCE	ND
	TCE	ND		TCE	ND
House 6					
March 28, 2001			August 22, 2001		
Living Space	PCE	ND	Living Space	PCE	ND
	TCE	ND		TCE	ND
Crawlspace	PCE	ND	Crawlspace	PCE	ND
	TCE	ND		TCE	ND

ND = not detected

Table 1 (cont.) *PCE and TCE indoor air concentrations (in micrograms/cubic meter) Palermo Valley residences, Tumwater, Washington*

House 7					
March 28, 2001			August 22, 2001		
Living Space	PCE	Not tested	Living Space	PCE	1.8 (= 0.27 ppb)
	TCE	Not tested		TCE	ND
Crawlspace	PCE	Not tested	Crawlspace	PCE	2.1 (= 0.31 ppb)
	TCE	Not tested		TCE	ND
Background (outdoor) air sampling results					
March 28, 2001: 5003 Rainier Ave. (ND)			August 22, 2001: 5003 Rainier Ave. (ND)		

Table 2 *PCE and TCE health comparison values (in micrograms per cubic meter)*

Chemical	Maximum indoor air concentration	Non cancer health comparison value	Cancer comparison values	Cancer risk at maximum concentration
PCE	2.1 (living space sample)	272 (chronic EMEG/MRL)	4.38 (MTCA B, CLARC II update) 3.1 (EPA Region 3)	1×10^{-7}
TCE	5.6 (crawlspace sample) 3.1 (living space sample)	537 (Intermediate EMEG/MRL) 40 (Inhalation RfC)	1.46 (MTCA B, CLARC II update) 1.0 (EPA Region 3)	1×10^{-6} 7×10^{-7}

EMEG = ATSDR Environmental media evaluation guide
MRL = ATSDR Minimal risk level
MTCA = Washington State Model Toxics Control Act

CLARC = Department of Ecology Cleanup Levels and Risk Calculations
Inhalation RfC = EPA Inhalation Reference Concentration

Table 3 *Contaminants of concern detected in indoor air, Palermo residences, Tumwater, Washington (in micrograms per cubic meter)*

Contaminant	Maximum Detected Concentration	Indoor Air Background Level Ranges (based on various studies)	Source of Indoor Air Background Level Ranges
Tetrachloroethylene (PCE)	2.1	0.4 - 9	Shah/Pellizzari
Trichloroethylene (TCE)	5.6	0.075 - 7	Shah/Pellizzari

Table 4 *Background levels of PCE and TCE measured in outdoor air, Palermo neighborhood, Tumwater, Washington (in micrograms per cubic meter)*

Contaminant	Palermo Background (Outdoor) Air Concentration	Outdoor Air Background Level Ranges (based on various studies)	Source of National Outdoor Air Background Level Ranges
Tetrachloroethylene (PCE)	Not detected	0.31 - 0.66	Shah/Wallace
Trichloroethylene (TCE)	Not detected	0.2 - 0.7	Shah/Wallace

Child Health Initiative

ATSDR's Child Health Initiative recognizes that the unique vulnerabilities of infants and children deserve special emphasis with regard to exposures to environmental contaminants. Infants, young children, and the unborn may be at greater risk than adults from exposure to particular contaminants. Exposure during key periods of growth and development may lead to malformation of organs (teratogenesis), disruption of function, and even premature death. In certain instances, maternal exposure, via the placenta, could adversely effect the fetus. After birth, children may receive greater exposures to environmental contaminants than adults. Children are often more likely to be exposed to contaminants from playing outdoors, ingesting food that has come into contact with hazardous substances, or breathing soil and dust. Pound-for-pound of body weight, children drink more water, eat more food, and breathe more air than adults. For example, in the United States, children in the first 6 months of life drink seven times as much water per pound as the average adult. The implication for environmental health is that, by virtue of children's lower body weight, given the same exposures, they can receive significantly higher relative contaminant doses than adults.

Reproductive Health Effects

Adverse reproductive health effects in women have been reported to be associated with occupational exposures to PCE in the dry cleaning industry. These effects included menstrual disorders and spontaneous abortions. However, limitations of these studies precluded a definitive association between PCE exposure and these health effects. *Levels of PCE and TCE detected in indoor air were well below levels at which reproductive effects were observed in the relevant animal studies. As a result, adverse reproductive health effects would not be expected.*

Developmental Health Effects

The developing fetus, children, and especially the developing nervous system may be particularly susceptible to the toxic effects of PCE. Animal studies suggest that PCE can cross the placenta and that TCA, a metabolite of both PCE and TCE, concentrates in the fetus. Unmetabolized PCE has been excreted in breast milk, and in one health study, was detected in an exposed infant with liver damage. Rats that were given oral doses of PCE when they were very young, while their brains were still developing, were hyperactive when they became adults. It is not known whether PCE may have similar effects on the developing brain in human babies.

In Woburn, Massachusetts, studies of residents exposed to drinking water contaminated with solvents, including PCE, suggest the possible association of exposure to PCE and eye/ear anomolies and central nervous system/chromosomal/oral cleft anomolies. However, it is unclear whether other confounding factors might have influenced these health outcomes.

Under certain conditions of exposure, TCE is also believed to affect the developing fetus. Children have also been identified as a potentially susceptible population. *The levels of PCE*

and TCE detected in indoor air were well below levels which caused developmental health effects in these studies. As a result, adverse developmental health effects would not be expected.

Conclusions

1). PCE was detected at low levels in indoor air at two of the seven residences tested, while TCE was detected at low levels in indoor air at one of the seven residences tested.

2). The levels of PCE and TCE detected in residential indoor air do not pose a non-cancer health hazard. A slight increased cancer risk was estimated for residents assumed to be exposed to the maximum detected level of TCE continuously over many years. However, this risk is similar to that expected to result from background exposure to TCE and PCE. *Exposures to the detected levels of PCE and TCE in indoor air pose no apparent public health hazard.*

- PCE and TCE levels detected in indoor air were well below levels that would result in adverse reproductive or developmental health effects.

3). Studies have shown that VOCs (such as PCE and TCE) are usually present at low levels in outdoor and indoor air in urban areas. Outdoor sources include automobile exhaust and industrial emissions, while indoor air contaminants often come from household cleaners, paints, carpeting, and building materials. As a result, background levels of VOCs in indoor and outdoor air are a source of exposure for residents living in urban environments. Health risks associated with background exposure can be similar to or higher than risks from localized hazardous waste releases to the environment. Based on the limited number of Palermo residences tested, it is not clear whether the source of the indoor air detections is the contaminated groundwater, or other unrelated background source(s).

Recommendations/Action Plan

1). Copies of this health consultation will be provided to residents whose homes were tested, EPA, and Ecology. Additional copies will be available upon request.

2). Follow up with residents' whose homes were tested should be conducted by EPA and DOH to explain the results of the indoor air analysis.

3). DOH should be notified if groundwater and/or surface water chemical concentrations increase, posing an increased potential health hazard to residences at the base of the Palermo bluff..

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Appendices

Certification

This Health Consultation was prepared by the Washington State Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

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